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BIOLOGICAL BULLETIN.

NOTES ON THE STRUCTURE AND DEVELOPMENT OF EMBIA TEXANA.

AXEL LEONARD MELANDER.

Delays in the spring rains of 1902 made Pease Park at Austin, Texas, an unusually good collecting ground for the entomologist during the early summer. Numbers of rare and interesting insects were flying about the *Sapindus* and *Eisenhardtia*, plants which grow profusely there. The now-running Shoal Creek had its share of swarming Ephydridæ. On the open ground in the cedar brakes several ants and a number of Microhymenoptera belonging to genera new to this country were obtained. In the midst of this profusion of insect life we were not greatly surprised on turning over a chance stone to discover the male of *Embia texana* on May 10. This was soon followed by the other forms of the species, so that now we are able to throw some light, at least, on the transformations of these insects.

The question of the sexes of these insects has long been an enigma. Owing to the fact that many of the species were taken in abnormal situations, as on exotic plants imported by nurserymen, but little has been brought to light regarding their habits. Winged, half-winged and wingless specimens of the different species have been taken. Even after dissection the winged ones were affirmed to be females in some species and males in the others. The nymphs were once supposed to be micropterous adults, corresponding with the neoteinic royal forms of the Termites. Of the wingless casts, some had the symmetrical abdomen of the female (larvæ and adult females) and some the asymmetrical genitalia of the male. Inasmuch as a complete series of practically but one of the species has been obtained, and this form has not been altogether correctly interpreted, it is not surprising that this disagreement existed.

The fortunate discovery of all the forms of the American species reveals the fact that the Embiidæ may be polymorphic. During the winter and spring our species exists in the larval state, with occasionally a chance female surviving the summer and living into the autumn in the same nest with her young. In early May the final moultings occur. At that time the larvæ destined to become females increase rapidly in size, and with the final moult their reddish mottled color becomes a dark chestnut brown or even a bronzed black posterior to the prothorax. No traces of wings are evident nor is there a lengthening of the antennal joints. The abdomen of the female retains the symmetrical termination of the larva, is covered apically with longer and denser hairs, the last ventral becomes longitudinally split, and the cerci remain each two-jointed and short. These large females are sluggish in movement, carrying the abdomen with a dorsal hump as does the larva. They still spin their web-nests with glands unaltered during their metamorphosis. They are often social and frequently live two or three in a nest, whereas but a single male develops out of a brood of larvæ. The same fact

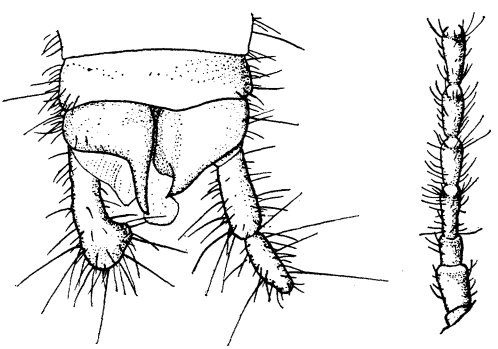

FIG. 1. *Male.* Tip of abdomen, and base of antenna.

has been observed in the case of *insularis.* However, in all collections of the Embiidæ the females seem to be much the rarer sex.

With the male the metamorphosis may proceed in one of two ways, *i. e.*, the males of *texana*, and of other species also, are dimorphic. At the penultimate moult wings may be formed, as in the Orthoptera, or not. In the former case a true nymph-

stage is attained. The body is but little larger than the full-grown larva, still of a pale reddish color, and marked with the same designs of irregular pigmentation. The antennal joints have the same magnitude and the cerci are two-jointed. Like the larva and adult female the abdomen is carried with the end bent down. The conspicuous change undergone at this moult is the acquirement of wing-pads. These are outgrowths from the anterior and lateral angles of the meso- and metathorax, which are folded over the dorsula, meeting in the median line, and attached by the basal part of their inner margin to the thorax, as in all true Orthoptera, and not as the misleading figure by McLachlan[1] would indicate. This stage has been observed in *insularis*, *Michaeli* and *Uhrichi*. Nymphs of *mauritanica* also have been found by Mr. Nathan Banks on date-palms imported from Algeria to Washington, D. C. The nymph-stage is of short duration, lasting probably not more than a week. Towards the end of that time the outer cuticle begins to separate. The single-jointed left cercus can be seen through the loosened chitin, extending into the second joint and reminding one of the figures of the Forficulid *Dyscritina*.[2]

With the last moult the habitus of the insect changes surprisingly. Full pigmentation and chitinization soon set in and the body becomes jet black with a bronzed tinge. Instead of the cylindrical form of the larva, the abdomen becomes depressed, and is now carried with the tip curved high over the back, altogether different from its former behavior. The front legs become inactive, and except during excitement, are never used for locomotion, being held helplessly in front of the body. The spinning glands of the front metatarsi do not cease to be functional, for the males were observed to spin, though always in a reluctant manner. The antennal joints lengthen, giving to these organs an increase of one half their former extent. The wings now become large, exceeding the tip of the abdomen, and also acquire their full pigmentation and villosity. When not in use they are carried flat over the back. As has been noticed for the other species the wings are attached firmly to the thorax and are

[1] *Jour. Lin. Soc. London*, XIII., Pl. Fig. 2*a*.

[2] See Green and Burr, *Trans. Ent. Soc. London*, 1898, Pl. XVIII.

in no manner deciduous. Hence the wingless male described below cannot be considered as a dealated form. Herewith is given a more detailed characterization of the male. Aside from the description of the wings it will apply for the wingless form mentioned later on.

EMBIA TEXANA Melander.

Male.—Length 6 mm., length of antenna 3 mm., length of wing 4.5 mm. Clear-cut, slender species. Body black, with violaceous or bronzed reflection; head, prothorax and front femora castaneous brown, middle and hind legs sometimes also brown, but darker; black-villose, the hairs variable in length and number. Antennæ black, the individual joints pale on their outer fifth, seventeen joints present, and these equalling a little more than one half the body-length, *i. e.*, reaching to the end of the metathorax, basal joint stout, cylindrical, a little longer than wide, second joint of less width, quadrate in profile, the remaining joints elongate-pyriform becoming elliptical terminally, the individual joints about as long as the basal two; all the joints are provided with stiff radiating black hairs. Palpi of same structure as in the larva, the maxillary palpi black, the labial reddish at the base. The lighter spaces of the head and thorax of the larva are much altered, becoming faint and indefinite in the adult. Propleuræ with two small sharp black tubercles in front of the coxæ. Thorax and abdomen as in the larva, but the chitinization and pigmentation much more advanced; penultimate segment (ninth including the segment mediaire) narrow, somewhat bullate dorsally towards the right; ultimate segment asymmetrically bisected dorsally, each portion produced more or less conically and pointed, in the middle of this armature, between the two titillatores a fleshy process may be exserted. Last ventral segment triangular, simple, but the left side is somewhat excised. The dorsal structure is not visible from below. The left cercus large, single-jointed, clavate, obliquely truncated apically, the right appendage two-jointed, with its outer joint shorter than the inner, both appendages hairy. Wings brown, marked with five secondary veins of wine-red pigment, the second and third connected by two to four cross bands of pigment, the third and fourth sometimes also connected. The central space of the cells is clear hyaline.

In this species the venation of the wings is much reduced, only the base of the subcosta, the radius, the cubitus, and the indefinite base of the anal vein exist as thickened cuticle; the original venation is represented by bands of wine-red pigment arranged like lines of granulations and by series of short hairs. These lines extend just posteriorly to the cuticular thickenings and represent the full venation of the nymph, except that the costa is wanting

in the adult. Owing to this double venation, which, judging from the figures, occurs also in a number of the other species, there has been much confusion in homologizing the veins with those of other insects. On applying the ontogenetic method of Messrs. Comstock and Needham, which fortunately the possession of nymphs of two species enables us to do, it will be seen that the interpretation given by these gentlemen of one of Wood-Mason's figures is nearly correct. It might be suggested, however, that the cross-veins are not to be regarded as branches of

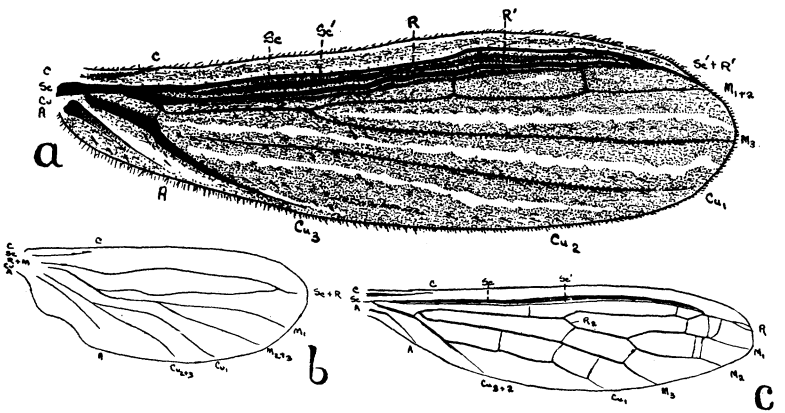

FIG. 2. *a*, wing of adult; *b*, wing of nymph; *c*, wing of *Embia Uhrichi*.

the radius, but as additional veins, for their position is very unstable, and moreover, in the nymph they are indicated merely by a sinuosity on the radius, very much as in *Psocus*,[1] from which type they do not materially disagree. *Texana* has the simplest type of true neuration of any of the species of this family, the veins being reduced to those thickenings mentioned before. Figures of its nymph-wing, which is also identical with that of *mauritanica*, and of the adult wing of *Uhrichi* (copied from Saussure)[2] are given for comparison. In the latter species the neuration reaches its highest degree of complexity.

If before the final moult wing-formation does not take place, the adult stage is attained in a wingless condition. These wingless males are more frequently met with in the nests than the winged form, though never more than one was to be found in a

[1] *Vide, American Naturalist*, XXXII., p. 241, Figs. 11 and 12.

[2] *Mitt. d. Schweiz. entom. Gesell.*, 1896, Pl. Fig. 1.

single nest, which often would contain several females. In color, size and structure both forms of the males are exactly similar. Moreover, they have the same movements, with forelegs elevated, though the wingless male generally carries its abdomen curved further over the back. Their only difference is in the matter of wings.

In the *Entomologists' Monthly Magazine* (1897, p. 56), Mr. R. C. L. Perkins notices a peculiar condition of the thorax of *Embia insularis*. From the hinder angles of the meso- and metathorax project small lobes which he concludes are the beginnings of the wing-pads at the stage immediately preceding the nymph-form. A specimen of a full-grown wingless male of *texana* presents the same peculiarity. This cannot be explained as a case of atavism — an attempt at the wing-formation which this form has lost — for the true wings arise from the anterior angles of these segments and hence are not homologous with these free lobes. Moreover, we have sectioned the fully-grown larva and find the wings as large invaginated pockets completely beneath the hypodermis.

The males of *Solieri* seem undoubtedly all to be wingless, although the evidence rests largely on the absence of winged forms. Professor Grassi and Dr. Sandias obtained numbers of mature wingless males but none with wings. However their observations were interrupted during July to September.

The structure of the anal cerci of the Embiidæ varies with the individual. The males of three species (*tartara*, *texana* and *Wheeleri*) have the left cercus always single-jointed and the right one two-jointed. As far as can be judged from the descriptions all the other species (except possibly *mauritanica*) have both appendages two-jointed in the male as well as in the female. It is among this latter class that the structure of the cercal joints varies.

Herewith is appended a table of all the described species of this family, indicating the extent of polymorphism as far as has been recorded. The localities of distribution are added to accompany the map given later on.

	larva.	♂ nymph.	♂ wingless.	♂ winged.	♀ wingless.	
1. *æthiopicorum* Karsh.				×		N. Camerun, W. Africa.
2. *agilis*[1] Sundeval.	×					Bahia, Brazil.
3. *antiqua* Pictet & Hagen.			×			Prussian amber.
4. *Batesii* McLachlan.				×		Brazil.
5. *bramina* Saussure.				×		Bombay, India.
6. *braziliensis* Gray.				×		Brazil.
7. *cubana* Hagen.	?			×		Cuba.
8. *hova* Saussure.				×	×	Madagascar.
9. *Hubbardi* Hagen.				×		Enterprise, Florida.
10. *humbertiana* Saussure.				×		Ceylon.
11. *insularis* McLachlan.	×	×	×	×	×	Honolula : Antigua Isl.
12. *mauritanica* Lucas.	×	×		×		Algeria.
13. *Michæli* McLachlan.		×	×	×	×	Ambulla, Calcutta, India.
14. *Muelleri* Hagen.					×	Sta. Cattarina, Brazil.
15. *nigra* Hagen.				×	×	Upper Egypt, Cairo Egypt : Kellemisch, Asia Minor.
16. *nobilis* Gerstecker.						Itaituba, Amazon, Brazil.
17. *persica* McLachlan.				×		Shahrud, N. Persia.
18. *ruficapilla* Burmeister.				×		Venezuela : Brazil.
19. *ruficollis* Saussure.				×		Central America.
20. *Salvini* McLachlan.				×		Tehuantepec, Mexico : Chinautta, Central America.
21. *Saundersii* Westwood.			×	×		Bengal, Jubbulpore, Calcutta and Bombay, India : Borneo : Mauritius: Madagascar: Ascension Isl.
22. *Savignyi* Westwood.				×		Egypt : Greece : S. Russia ?
23. *Solieri* Rambur.	×		×		×	Spain : France : Italy.
24. *tartara* Saussure.				×		Turkestan.
25. *texana* Melander.	×	×	×	×	×	Austin, Texas.
26. *trinitatis* Saussure.	×			×	×	Trinidad.
27. *Uhrichi* Saussure.		×		×	×	Trinidad.
28. *Westwoodi* Hagen.				×		Zanzibar ? copal.
29. *Wheeleri* Melander.			×			Cuernavaca, Mexico.

That the wingless males are functional is to be seen from the following interesting observation. On June 1 a male that had been kept in captivity for some time was admitted to the dish containing some isolated virgin females. At once every action denoted an intense excitement. The quivering of the antennæ, the tremors of the body, the hurried runs hither and thither, and the gnawing at the web, were all strangely in contrast with the passive demeanor in the former nest. His entire behavior indicated that his senses perceived the proximity of the other sex. At last a run brought him beside one of the females. A sudden

[1] This species, described as the larva of a new genus of Forficulidæ, *Condylopalama*, will probably never be recognized from the brief description.

calm overcame him, and with his mouth and the fore feet that normally are so inactive, he caressed the head and thorax of his bride. This lulled her to tranquility, and with a sudden dart the male turned around and clasped the eighth ventral in his bifid pygidium. Instantly both were struck with a rigor. They allowed themselves to be turned over without showing a sign of movement, and were it not for the rapid but faint pulsation of the thinner chitin of the segmental interstices of the male they would have seemed as if dead. For four and one half minutes they remained thus, the body of the male twisted over the back of the female, and turned towards her right side. The copulation then being effected they separated, and both ran about with the quiet movements of their ordinary gait. Now we understand why the male so frequently carries the tip of the abdomen uplifted for this position has a functional significance during coition. During this time the heart-beat of the male attains three hundred per minute. This pulsation is remarkable when we remember that the highest number recorded is one hundred and forty-two per minute for *Anthophora*, and that, too, at a time of excitement.

Distribution.

All of the specimens of *texana* were taken in the same situations as were the larvæ described in the June number of this periodical, under flat limestone surface-rocks that form so prominent a feature of this region of the Texas country. Net-sweepings through the grass in the vicinity failed to reveal any specimens. This is to be expected, however, for our species is practically nocturnal. In the case of *mauritanica*, specimens have been taken in grass-sweepings during the daytime, while *nigra* has been found in the same way in the evening. The situations frequented by the different species present quite a range of variation. Some have been found among the roots of orchids where they are said to cause considerable injury (*insularis*, *Michaeli*, etc.). Many construct their web-nests on the fibrous bark of palms and cycads (*Saundersii*, *mauritanica*, *Uhrichi*, etc.). The former species, too have been seen running about on the sand. The habits may vary with the altitude, even. *Insularis* becomes arboreal in high situations but is found under stones in the low-

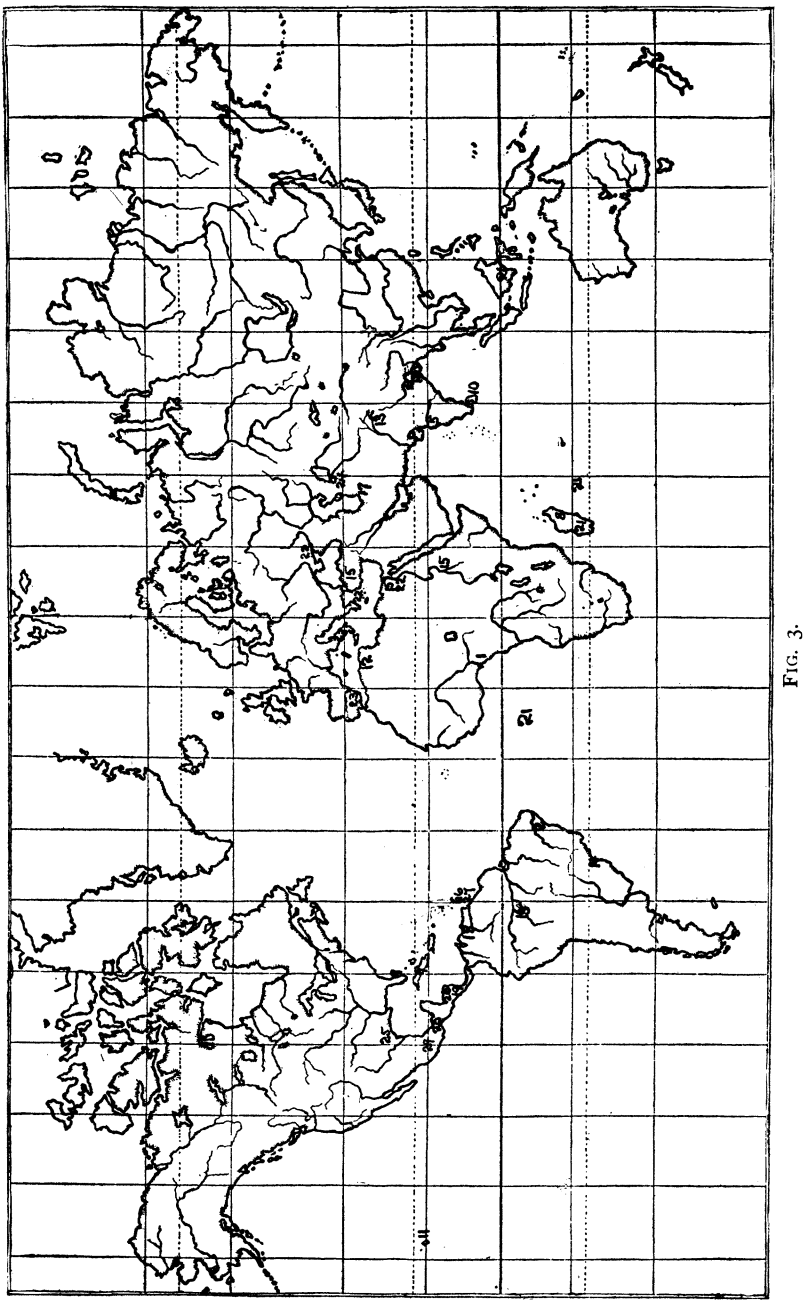

FIG. 3.

lands. During the night the males of this species fly freely to lights. A similar habit has been noticed with the Indian species.

All of the species, however, require a very definite degree of moisture and hence are restricted in their distribution along the seacoast. A glance at the accompanying map will make this evident. Here are plotted the known *patriæ* of the various species, numbering the localities to correspond with the list of species given before. Where the identification is doubtful a cross expresses the provenience. A comparison of the available and recognizable descriptions of previous authors brings to light several facts. The old group *Olyntha* (represented by species 25, 29, 20, 27, 6, 18, 4, 14, and probably by 19 and 26) though untenable as a genus, yet is comprised wholly of American forms. The only other American species, *Hubbardi* and *cubana* are related among themselves and very closely with the Sandwich Island species, *insularis*, which is said to occur in the West Indian island Antigua also. Moreover, *insularis* is a near relative to *Saundersii* (21) which has an extended distribution over Borneo, India, Mauritius, Madagascar and Ascension Island. With this species are grouped also the Indian species, *Michaeli* (13) and *bramina* (5), and possibly also *humbertiana* (10, from Ceylon) and *hova* (8, Madagascar), themselves closely allied and forming small groups. *Mauritanica* (12) and *Savignyi* (22) are stated to be close relatives, and both live along the southern Mediterranean coast. *Nigra* (15) of Egypt is represented by a variety (?) in Asia Minor. Thus we find a number of groups, natural both in structure and in distribution. The New World forms, excepting those of the West Indian fauna, which probably are derived from an oriental source, stand out alone. *Embia Solieri* (23) of southern Europe has little affinity with the other species, its nearest relative being *antiqua* (3) from the Prussian amber, of Tertiary times, a form also with wingless male, and not clearly distinguishable from the living species. India seems to be the point of expression of another group of species (species 13, 5, 21, 10); of these *Saundersii* (21), or forms indistinguishable from it, occurs with a wide island-distribution. It seems to be with these species that *cubana* and *insularis* are to be grouped. Australia, eastern Asia and western South America are, as far as

known, destitute of species. The Embiidæ are therefore seen to be tropicopolitan and also seacoast species, extending only a few hundred miles into the interior along the principal water-courses. In the warmer countries they appear at higher altitudes, in order to preserve conditions of proper temperature and humidity. As the species show a preference for palms and orchids, plants which have a commercial importance, it is not surprising that their distribution is artifically complicated. At least four species have thus been taken in ship-yards and green-houses thousands of miles from their native homes. Moreover, a natural maritime distribution is quite possible on tree-trunks swept down some river during flood-time and then carried about by ocean currents. *Texana* has actually been found under the bark of a fallen tree lying on a flood-plain. The next heavy rain would have carried that tree-trunk down the Colorado River and ultimately to the Gulf of Mexico. These facts should be remembered when we consider the wide distribution of *Saundersii*. It might be mentioned that like so many other introduced animals this species has become exceedingly abundant in some places, even to a source of annoyance in the island of Ascension. *Insularis*, too, is said to be common on the sea-shore, every stone serving to shelter two or three. This fact might indicate an introduction during times not distant, with conditions favorable for a rapid increase in numbers, and only recently an extension into the interior.

That the Embiidæ form an ancient group is undisputed. Their uniformity of structure, so marked that characters of specific importance are few, shows that they have long passed the zenith of their evolution. The variability of the antennæ and of the cerci, and even of the neuration of the wings might suggest a decadence of these organs. The fact that the males are dimorphic and have only partially the need for wings, retaining them possibly only to prevent too close interbreeding, while the females are all wingless, also would lead us to that conclusion. But the Embiidæ have existed a long time in this dimorphic condition of the male, for the wingless form is known in amber from the Tertiary. This family of frail insects, one of the first of the twigs of the great Orthopteran branch, seems certainly in process of extinction, but like other groups which were conservative in special-

ization, they too are destined to outlive many of their later but more plastic companions.

International Anatomy.

The forepart of the alimentary canal consists of a small buccal cavity, a narrow pharynx, dilating into the large œsophageal tract, which extends into the metathorax. The central part of the œsophagus is narrowed, as in *Solieri*. At the hinder end of this portion there is formed by a sudden constriction a narrow tract which terminates that part of the alimentary canal of stomodæal origin. Thus far the tract is lined with a chitinous cuticle presenting differently formed teeth along its course, and is enclosed within a double layer of muscles — the inner layer longitudinal, the outer circular — which become stronger posteriorly. The teeth of the buccal cavity are closely placed, long, directed backward, and attached in sockets. In the pharyngeal constriction they become minute and flattened, more closely aggregated, still directed backward, but appearing like small ctenoid-scale-

FIG. 4. Diagrammatic arrangement of the body-organs in a medial sagittal section. *an*, anus; *malph*, malpighian tubule; *ov*, oviduct; *rect*, rectum; *rect. gl*, rectal gland; *sth*, spermatheca.

like projections of the cuticle. Below the frontal ganglion of the sympathetic system the scales are wanting but recommence further on. The pharynx is thrown into eight strong longitudinal folds, of which two are lateral, two ventral, and four dorsal. This gives to a trans-section of the pharynx a hexagonal, not octagonal, appearance. Within the proventriculus the teeth are reduced to mere granulations of the cuticle, arranged in narrow scattered areas.

The mid-intestine commences as a sudden enlargement more or less telescoping with its pedicel, and which gradually narrows to the point of attachment of the Malpighian tubules in the sixth

segment of the abdomen. Its walls consists of columnar epithelium — short uniform cylindrical cells in the larva and elongate, more or less pear-shaped, irregular, secreting cells in the adult. The muscular layer surrounding the mid-gut is much reduced, and the chitinous lining of the fore-gut is wanting in this portion. At the base of the Malpighian tubules the wall of the mid-intestine is thickened, forming the gastro-ileal valve. Here, in a conical chamber formed just beyond the valve, commences the cuticle from the proctodæal invagination, but unlike the œsophageal chitin, it is thin, replicated and smooth. The ilium is normally much contorted, but when filled with food can be straightened. Its numerous circular muscles then force it tense and crowd the mid-gut into the thorax. The globular rectum fills out the last two segments of the abdomen. When not evacuated it is filled with rasped wood and other fragments of vegetable origin. Its walls are strongly bulged by the six large cushion-like rectal glands which consist of long convoluted secreting (?) cells each with a large central nucleus. The Malpighian tubules vary in number with the age of the individual, becoming about twenty-four in the adult. In the younger stages they are rather shorter and thicker with their nuclei more aggregated, *i. e.*, their cells are smaller. Their cells frequently present a honey-combed structure, probably due to the solution of their contents in the reagents for clearing.

The heart of *Embia* can be distinctly seen through the overlying translucent chitin, extending the length of the body. Even when pigmentation is greatest the heart is still evidently visible from above. The blood corpuscles are large and elliptical.

The supraœsophageal ganglion (brain) of the nervous system is relatively small; the optic lobes send off a stouter nerve to the eyes than is apparently the case in Professor Grassi's species. This may be in part due to a difference in the power of sight in the two species. The deutocerebrum is flattened, the antennal nerves very slender, an innervation that might be expected for organs of so poor sensory development. Owing to the absence of ocelli there are naturally no ocellar nerves. The subœsophageal ganglion is comparatively large, sending an anterior nerve in front of the œsophageal commissures. The remainder of the

nervous system is nearly similar to that of *Solieri*, consisting of three large thoracic ganglia and seven smaller abdominal ganglia connected by the double ventral cord. The fifth segment is, as has been noticed in *Solieri* and *Uhrichi*, destitute of a ganglion, the ventral cord between the fourth and fifth ganglia being longer than between the others. But in our species the last ganglion (seventh abdominal) is crowded forward, though still remaining larger than the other ganglia of the abdomen. Its position is above the seventh sternite and contiguous with the ganglion in front. In the two species before compared the last ganglion is connected with the sixth by a commissure and is placed in the eighth segment. Each of the ganglia send side branches into the viscera, while the last terminates in a pair of nerves interwoven with the efferent sexual ducts.

The visceral system is somewhat different from that of *Blatta*.

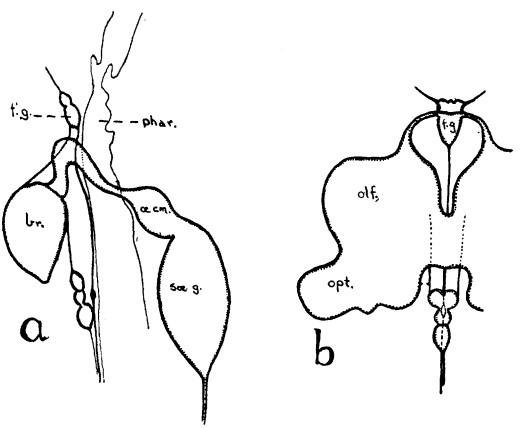

FIG. 5. *a*, lateral; *b*, dorsal view of the cephalic nervous system; *br.*, brain; *f. g.*, frontal ganglion; *œ. cm.*, œsophageal commissure; *olf.*, olfactory lobe; *opt.*, optic lobe; *phar.*, pharynx; *sœ. g.*, subœsophageal ganglion.

It consists of an unpaired triangular frontal ganglion of rather large size, connected laterally by stout commissures with the anterior lobes of the brain. The lower portion of this ganglion ends laterally in nerves extending obliquely forward along the œsophagus. The frontal ganglion ends posteriorly in a long slender nerve lying immediately above the coat of circular muscles of the alimentary tract, and enlarged as two ganglia over the

œsophageal portion, one within the prothorax, the other in the mesothorax, though still lying close over the œsophagus. At intervals this nerve sends off a series of fine nerves anastomosing in minute knots and which terminate within the circular muscles of the tract. The remaining ganglia are unpaired also, lying in the median line above the alimentary tract and within the hind fork of the brain. These are three in number, more or less fused, and the anterior one bilobate. They send but one slender nerve backward, above the one from the frontal ganglion, and are connected with the brain by two commissures arising from the sides of the anterior bilobed ganglion. As the peripheral nerves of this system intimately innervate the muscles of the alimentary tract, conforming with all its irregularities, it would seem that peristalsis is controlled from this source. Professor Blandford did not find the posterior ganglions of the visceral system of *Uhrichi*. This was probably due to their small size in the specimens studied rather than to their complete absence. All the ganglia vary in size almost more than do the other organs of the body. In some cases the posterior ganglia of the visceral system are much reduced and flattened.

The female generative organs agree with the descriptions of those of *Solieri* and *Uhrichi*, consisting of a paired oviduct, each branch of which emits five lateral tubules. In the larval state the tubules are consolidated into a compact elliptical mass, situated dorsally one to each of the five basal segments of the abdomen. Each mass comprises about seven transverse chambers and is connected with the slender oviduct by a short and equally slender strand. In the adult the tubules lengthen by a forward growth, the chambers separate and on becoming elliptical give a moniliform appearance to the tubule. The end-cells remain undifferentiated. In a multiparous female the oviduct becomes greatly distended and its walls much wrinkled. This distension is evident also at the base of the recently emptied follicles. The spermatheca is large, occupying the free portion of the eighth segment. It opens below by a somewhat tortuous duct into the short vagina. The end of the ventral nerve chain passes between the vagina and the spermatheca.

Embryology.

During the few weeks the Embias were kept in captivity the females deposited a small number of eggs. These were laid during the night-time, generally one at a time, and were often insecurely fastened to the surface of the jar by strands of silk. The eggs, a dozen or so in number, were carefully preserved in hope that the history of the embryos would give some clue as to the systematic position of the family.

The eggs are of a creamy-white color and of the retort-shape noticed in *Solieri* and *Uhrichi*, and possess a characteristic narrow circular band of thickened chitin extending obliquely from the apex of the narrower end to one third the distance along one side. This structure is of great service in orienting the egg during the later stages. In the ovaries of the female the eggs lie with the narrowed end anteriorly and the oblique surface directed upward and towards the median line of the body. Thus the primitive ventral surface does not correspond with the definitive, but the anterior end of the ovarian egg remains the anterior end for the hatching embryo. The oblique circle outlined by the ridge is doubtless detached at the time of hatching. The chorion is thin but firm, and presents a smooth finely granular surface. Within the circle, however, the surface is lightly roughened by trabeculæ and minute pillars, its alveolar structure corresponding with the enlarged cells of the follicular epithelium. At the posterior median point of the ridge is a small elliptical opening, the micropyle, communicating with the irregular lumen of the ridge itself. This opening is in connection with a smaller one passing into the interior and provided with a grooved guideway. As in *Blatta*, no gyration of the egg is necessary, during the passage down the oviduct; the micropylar opening comes directly in contact with the mouth of the spermatheca, while the small size of the opening limits the number of spermatozoa that find ingress. The chorion is sometimes thin, due to imperfect secretion, and at times is covered by the shed follicular epithelium. In this detritus and among the strands of silk particles of soil adhere. This might indicate that in the natural nests the eggs are concealed for protective purposes by an added covering. The vitel-

line membrane is comparatively tough and separates from the chorion in eggs kept in an alcoholic preservative.

Unfortunately the youngest embryos were well advanced at the time of preservation, being in an elongate fully-segmented stage. As the embryo now extends over the whole of the definitive dorsal surface with its head directed posteriorly, it probably attained this position by rotation, keeping at the surface of the egg as in the Termites and not plunging through the yolk as in the Orthoptera with elongate eggs. At this stage segmentation is nearly complete, only the posterior end being confused. The antennæ are short, borne by the rather large deutocerebrum which shows a flexure around the posterior pole. The mouth

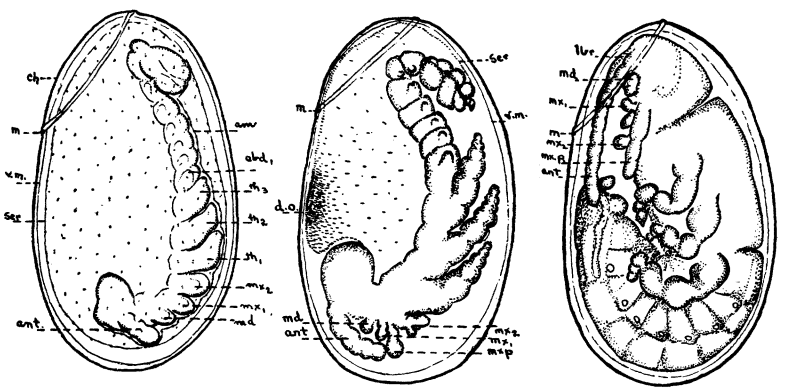

FIG. 6. Three stages of the developing embryo. *am*, amnion; *ant*, antenna; *ch*, chorion; *do*, dorsal organ; *lbr*, labrum; *m*, micropile; *md*, mandible; $mx_{1,2}$, maxillæ, *mxp*, palpus; *ser*, serosa, $th_{1,2,3}$, legs; *v. m*, vitelline membrane.

parts are large, single-jointed appendages, the labrum distinctly bipartite. The head segments are nearly as strongly marked as the thoracic. Of the limbs the first pair are slightly more advanced than the others. Whether this is due to the antero-posterior direction of growth or to an acceleration of these important appendages would be hard to decide. The pleuropodia are large, the remaining abdominal appendages are uniformly smaller and disappear on the fifth segment. Beyond this segment the abdomen curves into the yolk, while at the eighth segment there is a sudden outward flexure. The "tail-piece" thus formed is quite like the similar growth of *Termes*, etc. Sections of the

egg reveal only the usual envelopes over the embryo, *i. e.*, the chorion, the tough vitelline membrane, the serosa with large nuclei, the amnion with smaller more rounded nuclei, and the blastodermhaut. The yolk of these eggs, fixed by hot water, shows a definite segmentation, a dozen or so of granules being aggregated about each vitellophag.

During the next few days the embryo changes rapidly in appearance, due to the process of shortening, *i. e.*, broadening. The appendages lengthen, the mouth parts take on their final structure and position, the maxillæ becoming tripartite, much like *Termes*, due to the development of their palpi. The head, however, still continues its accelerated development, but lies free from the yolk. The abdominal legs still persist, though even yet, except for the terminal styles, none are formed on the "tail-piece," which is more flexed than before and in which the proctodæum is seen in process of formation. The serosa and amnion have parted over the embryo and are drawn back as the "dorsal organ."

The last stage of which we have material shows a marked advance in development, although the embryo is but three weeks old. Revolution has now occurred. The envelopes, except the vitelline membrane, as well as the dorsal organ, have disappeared. The embryo has grown over the yolk, but the dorsal abdominal cuticle is still thin and shows its derivation from the serosa by scattered nuclei over its surface. The proctodæum and stomodæum are well formed but still are separated from the yolk-mass. The head-lobes have dwindled to a microcephalic size, the antennæ have lengthened to the base of the fore legs, but even now the maxillary palpi are nearly as long; yet the antennal segmentation is more marked than in the corresponding stage of *Xiphidium;* the labrum is large and separate; the eyes are not yet formed. The tarsi are now suddenly flexed outward, with the front metatarsi distinctly large. The abdomen is stout and much bent on itself. The appendages, except the cerci, have disappeared, and in their stead conspicuous spiracles are developed.

From the rapidity with which these stages are passed through it would seem as though the embryonic life of *Embia* is of short duration. A development at this rate would cause hatching to

occur in late June, at the very height of the dry season. But as these frail insects cannot undergo heat and drought, as has already been shown, it seems not improbable that soon after the last stage described above there is an arrest in development which enables the embryo to æstivate within the protecting chorion until the rains of later summer. Under the conditions of Texas weather it does not seem likely that there are two broods a year. Moreover, from autumn till spring there is a gradual increase in the size of the larvæ observed.

The few stages obtained show nothing but what might be expected in the development of this insect, and simply indicate that the position of the Embiidæ in the superorder Orthoptera is doubtless correct. The latter part of the embryonic history, at least, shows a closer parallelism with the Termitidæ than Grassi's conclusions drawn from the adult structure would lead us to expect. At any rate, the comparatively large size of the head of the young embryo, the persistence of the abdominal legs and the structure of the appendages and of the "tail-piece" might have some phylogenetic bearing. The late formation of the eyes, the enlarged front metatarsi, the relative sizes of the antennæ and maxillary palpi are marks of specialization, indicating arrested or precocious development, and are not to be sought for beyond the ontogeny of this form.

Summary.

The females of the Embiidæ are comparatively large, wingless and symmetrically formed, the males have the abdomen more or less distorted (except species 17, 18 and 22). The males of probably all the species are dimorphic, being wingless (not dealated) or winged. The wings arise from invaginations at a pre-nymphal instar. A nympha-stage with larva-like body is undergone. Venation varies with the species, and generally is double, represented by true veins and pigment lines. The thickened veins of *texana* are few. Copulation occurs within the nests. The carriage of the male abdomen is attributable to its function. The facets of the Embiid eye are quite like those of a newly-hatched grasshopper.

The entire family is tropicopolitan and prefers the humidity of

the coast-region. Its extended island-distribution appears to be in part artificially effected. Brazil, the Mediterranean region and India seem to be the points of differentiation of the groups *Olyntha*, *Embia* and *Oligotoma*, respectively.

The internal anatomy presents a generalized type. But little change is undergone during metamorphosis. The oviducts of an old female may be as large as the alimentary tract. The females have all available space occupied by the fat body and later by the developing eggs. The brain is much less developed than the ventral nerve chain. The visceral system comprises four prominent unpaired cephalic ganglia.

Embryonic growth is completed in about a month. The eggs have a unique micropylar apparatus and are not oriented in the female in their definitive position. The history of the embryo conforms with the Orthoptera, of which group the family is considered as a conservative and ancient branch.

HULL ZOÖLOGICAL LABORATORY,
THE UNIVERSITY OF CHICAGO.